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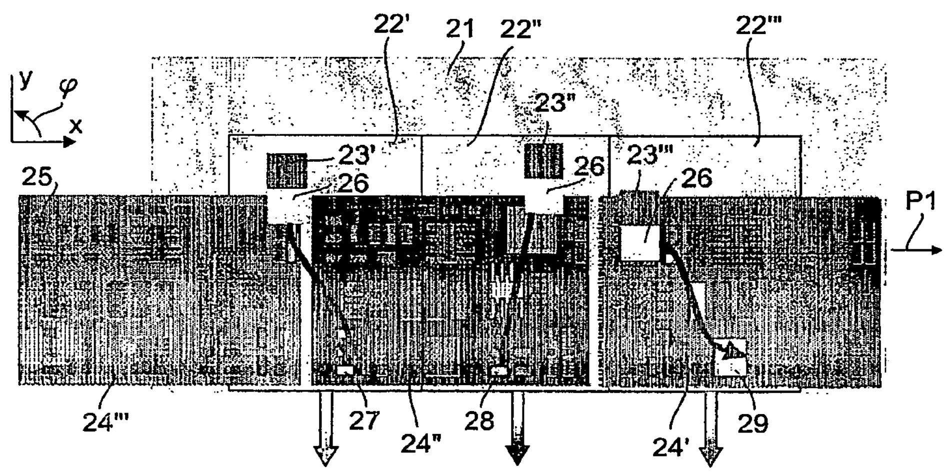
(54) Title: METHOD OF PLACING AT LEAST ONE COMPONENT ON AT LEAST ONE SUBSTRATE AS WELL AS SUCH A SYSTEM



(57) Abstract: A method of placing at least one component (25) on at least one substrate (24), a component (25) being picked up by means of at least a placement machine (2) and placed on a desired position on the substrate (24). After the component (25) has been placed on the substrate (24), an image of the component (25) placed on the substrate (24) is made by a camera (5, 23), a difference between the real position of the component (25) on the substrate (24) and the desired position of the component (25) on the substrate (24) being established on account of the image. The positioning of a next component (25) to be placed is adapted on account of the difference found.

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Method of placing at least one component on at least one substrate as well as such a system

The invention relates to a method of placing at least one component on at least one substrate, a component being picked up by means of at least a placement machine and placed on a desired position on the substrate.

The invention also relates to a system suitable for executing the method as claimed in one of the preceding claims.[sic]

In such a method and system known from United States patent US-A-5,880,849 an image of a substrate is made by a camera. From the image thus made a desired position relative to the substrate of a component to be placed on the substrate is established. Then the placement machine is driven and the component is placed on the substrate. By means of the method and system known per se, however, it is not possible to carry out a check to find out whether the component is really placed on the substrate on the desired position.

Therefore, it is an object of the present invention to provide a method in which the placement of a component on a substrate can be improved in a simple manner.

This object is achieved by the method according to the invention in that after the component has been placed on the substrate, an image of the component placed on the substrate is made by a camera, a difference between the real position of the component on the substrate and the desired position of the component on the substrate being established on the basis of the image, after which the positioning of a next component to be placed is adapted on account of the difference found.

From the image produced by means of the camera, the real position of the component relative to the substrate can be determined in a simple manner. A difference is then established between the desired and real positions of the component placed on the substrate. If the component is correctly positioned on the substrate, there will not be any difference between the desired and real positions of the component on the substrate.

However, if there is a difference indeed, in the method according to the invention this difference is taken into account for the placement machine drive when a next component is positioned on the substrate. The camera can either form part of the placement machine or form part of a device set up next to or at a distance from the placement machine. Finding the difference between the real and desired positions as well as adapting a positioning of a next component based on the difference found, may take place both on line and off line.

An embodiment of the method according to the invention is characterized in that first a same kind of component is placed on a number of substrates on substantially the same positions, while differences between the desired and real positions of the components relative to the associated substrates are determined, the positioning of a next component to be placed on a next substrate being adapted on account of the differences found.

In this manner deviations between the desired and real positions of the component due to incidental deviations, for example due to what are called stochastic errors such as friction in the placement machine, dynamic vibrations, measuring error etc. over a number of substrates are processed when the positioning of a next component is adapted and an error remains which will repeat itself at nearly every substrate. This error is for example the result of calibration rest errors, the stretching of the substrate due to temperature changes, machine wear, errors in a relatively large number of the same substrates relative to the expected and real location of for example track patterns on a substrate etc. Errors like these are called deterministic errors.

When the deviations are processed, deviations in substrates that have already been manufactured earlier are counted less strongly than deviations in a substrate that has been manufactured just before the substrate now to be provided with components.

A further embodiment of the method according to the invention is characterized in that first on at least one substrate a number of different components are positioned, the real positions of which are compared with the desired positions, subsequent to which the positioning of a next component to be placed on the substrate or another substrate is adapted based on a statistically determined average difference.

In this way the differences are determined of for example all components placed by a certain placement machine.

A further embodiment of the method according to the invention is characterized in that once a number of components have been placed, the real positions are compared with the desired positions.

In this way determining the real position of the component relative to the substrate can take place independently of the placement of the component on the substrate. A disadvantage of this, however, is that not until a number of components have been placed will there be established whether these components have really been positioned on the desired position and only after that will a feedback be realized.

Another embodiment of the method according to the invention is characterized in that once each component has been placed, the real position is compared with the desired position.

In this way there is a direct coupling once a component has been placed. If the time for determining the difference between the real and desired positions of the component is relatively short, this does not have a disadvantageous effect on the time necessary for placing the component.

Yet another embodiment of the method according to the invention is characterized in that components are placed on at least a substrate by means of a number of placement machines located side by side, each placement machine comprising a camera by means of which an image of at least a portion of the substrate is produced to determine the difference between the desired and real positions of the component placed on the substrate.

In this way it is possible to examine a portion of the substrate by means of each camera, which enhances accuracy whereas the time required for analyzing each image remains relatively limited.

The invention also has for an object to provide a system with which components can be placed on a substrate more accurately.

This object is achieved with the system according to the invention by the system being provided with at least a placement machine and a camera cooperating with the placement machine, an image of a component positioned on a substrate by means of the placement machine being producible by means of the camera, the placement machine further being provided with a control scheme by means of which a real position of the component relative to the substrate as well as a difference with a desired position of the component relative to the substrate can be determined from the image produced by the camera.

In this manner a difference between the real position and the desired position of a component on a substrate can be determined in a relatively simple manner. If the placement machine already has a camera, for example, for determining the desired position on the substrate with the camera, an image can be made by the same camera both prior to and

subsequent to the placement of the component, and no separate camera needs to be added to the placement machine.

The invention will be further explained with reference to the drawings in which:

Figs. 1 – 5 show plan views of various embodiments of systems according to the invention,

Figs. 6A – 6C show plan views of a system according to the invention showing substrates on the different positions,

Fig. 7 shows a perspective view of a system according to the invention,

Figs. 8A – 8D show different ways of analyzing an image,

Fig. 9 shows a control diagram of a method where feedback takes place in line, and

Fig. 10 shows a control diagram of a method where feedback takes place off line.

Like components in the Figures are denoted by like reference numerals.

Fig. 1 shows a system 1 for placing components on a substrate, which system 1 comprises three placement machines 2', 2", 2'" located side by side. The substrates to be provided with the components are transported through the system 1 in the direction indicated by arrow P1 by means of a transport system 3. Such a system is known per se from United States patent US-A-5,880,849 mentioned above and will therefore not be further explained.

Downwards of the system 1 is located a machine 4 that has a camera 5 by means of which images of a substrate provided with components can be produced. The images made by the camera 5 are fed to a control diagram 6 (Fig. 9). The positions of components placed on the substrate relative to the substrate are determined by means of the control diagram 6. The control diagram 6 further contains the desired positions 8. In element 83 the difference between the desired positions 8 and the real positions 7 is determined by means of the control diagram 6. The difference E =)Y is subsequently fed to a controller 9 included in the control diagram 6, in which controller 9, after filtering by a low-pass filter 10, a feedback 12 is calculated by means of a calculation algorithm 11, which feedback serves to adjust the control of the individual placement machines 2', 2", 2'". The difference E may

include both deviations in X, Y and N-direction. This feedback 12 may be adjusted per machine. In this way it is possible to increase the accuracy with which a next component is placed on a next substrate. In the embodiment shown in Fig. 1, the systems 1 and 4 form separate systems.

In the embodiment shown in Fig. 2 the machine 4 is integrated with the system 1 and is installed adjacent to placement machines 2', 2". The functioning of the system shown in Fig. 2 corresponds to that shown in Fig. 1.

Fig. 3 shows another embodiment of a system 21 according to the invention which comprises three adjacent placement machines 22', 22", 22"' which are each provided with an associated camera 23', 23", 23"' as well as a control diagram belonging to each camera. By means of the system 21 shown in Fig. 3 the deviation between the real position of the component and the desired position is determined by means of the camera 23', 23", 23"' present in the machine 22', 22"and 22"' immediately after the placement of component on a substrate. In this way there is direct feedback 12.

Fig. 4 shows an embodiment of a system 31 according to the invention which comprises a system 1 shown in Fig. 1, a placement machine 32 installed beside it and a system 4 installed beside the latter. The operation of the system 31 shown in Fig. 4 corresponds to the system shown in Fig. 1. An advantage of such a system is that not each individual placement machine needs to have a camera. A disadvantage, however, is that from a substrate on which a component has been placed by means of a placement machine 2' the real positions of the components are not determined by means of the machine 4 until already a relatively large number of other substrates have been provided with components by placement machine 2'. In this way feedback is relatively slow.

Fig. 5 shows yet another embodiment of a system 41 according to the invention in which a system 42 is installed between the system 1 comprising placement machines 2', 2", 2"' and the system 4, with the aid of which system 42 the component placed on the substrate is affixed to the substrate. Such a system 42, such as, for example a wave soldering device, is known per se and will therefore not be further explained. While the component is placed on the substrate, undesired displacements of the components relative to the substrate may occur which are not caused by placement inaccuracies.

Figs. 6A 6C show the system 21 represented in Fig. 3, in which each placement machine 22', 22", 22"' comprises an associated camera 23', 23", 23"'. This system 21 largely corresponds to the system known from United States patent US-A-5,880,849. In the system shown in that patent cameras 23', 23", 23"' are used only for

determining a desired position of a component on the substrate and not for determining the real position of the component on the substrate subsequent to the placement of the component on the substrate.

In the situation shown in Fig. 6A, three substrates 24', 24", 24"' are located in the system 21. For simplicity the substrates show both the components 25 already placed and the components 25 still to be placed. Once the substrates 24', 24", 24"' have been situated in the placement machines 22', 22", 22"', a pick-up 26 mounted beside the camera 23' picks up a component from a feeding device (known per se) by the displacement of the pick-up 26 and the camera going with it in the directions shown by the arrows X, Y. Then a desired position on the substrate 24"'- 24' is determined with the aid of the camera 23'- 23"' after which the component is placed on the substrate by means of the pick-up 26. Then an image of a portion of the substrate 24'- 24"' is made by means of the camera 23 - 23"'. This may be the portion on which a component is placed by means of the respective placement machine , but it is alternatively possible during the displacement of the pick-up and the associated camera 23'- 23"' to make several substrate images of portions that accommodated components already at an earlier time. In the situation shown in Fig. 6A an image of the component 27 on substrate 24"is made by camera 23', an image of the component 28 on substrate 24"is made by camera 23", an image of the component 29 on substrate 24' is made by camera 23"'.

Then the substrates 24' – 24"' are moved in the direction indicated by arrow P1 after which the substrate 24" is largely located in the machine 22"', the substrate 24"' is largely located in the machine 22'and partly in the placement machine 22"and a new substrate 24"" is partly located in the placement machine 22'. Subsequently, components are placed on the substrates 24"- 24"" by means of the pick-ups 26, after which the camera 22'produces an image of the component 51 on substrate 24"", the camera 23"an image of the component 52 on substrate 24''' and the camera 23''' produces an image of the component 53 on the substrate 24''.

Positions of measured components on substrate 24'' can be corrected when components are placed on substrate 24'''. This provides a relatively fast feedback.

After the substrates have again been moved in the direction indicated by the arrow P1, the situation shown in Fig. 6C is obtained. In like manner as described above, a camera 23'produces an image of a component 54 on substrate 24''''', a camera 23'' produces an image of a component 55 on substrate 24'''' and a camera 23''' produces an image of a component 56 on substrate 24'''.

From the images thus produced can now be established from for example substrate 24''' the position of both component 52 and component 56 relative to the substrate. In the situation shown in Figs. 6A – 6C each camera produces only one image of a single substrate. It may be obvious that while the cameras 23'' – 23'''are moved over a substrate in the XY plane, various images can be produced. By means of a control diagram these images are then combined to a complete image of a single substrate, so that information about the positioning accuracy of a number of components on a substrate can be obtained.

Fig. 7 shows a perspective view of a system 61 according to the invention, which largely corresponds to the system shown in Fig. 1 with a separate, camera-equipped machine 63 being installed side by side with a placement machine 62. This Fig. 7 clearly shows that producing an image of a substrate 24' and determining possible corrections therefrom can only have an effect on a substrate that is located totally on the left in the situation shown in Fig. 7, but cannot have an effect on the three substrates 24 situated therebetween. As a result, the feedback is relatively slow but does occur.

Figs. 8A – 8D show a similar image 71 from which, however, the desired information can be derived in dependence on the desired positioning accuracy, the desired speed etc.

In the image 71 shown in Fig. 8A the arrows 72 indicate that from each of the components 25 present on the substrate 24 the real position of the component 25 relative to the substrate 24 is determined. Then in the control diagram 6 the real position of each component 25 is compared with the desired position. It may be evident that such a process requires relatively much calculation time in the control diagram 6.

Therefore, it is alternatively possible to determine, as is shown in Fig. 8B, the real position relative to the substrate 24 of only a few components 25. The amount of information to be fed to the control diagram 6, which information is shown by means of arrows 73, is considerably smaller than in the situation shown in Fig. 8A. Preferably the components 25 are then selected whose positioning accuracy has to be relatively great to guarantee a proper functioning of the substrate 24.

In the situation shown in Fig. 8C the arrows 74, 75, 76 indicate that only the real position of a number of components 25 is determined which are positioned by means of the placement machines 22', 22", 22"'. In this way it is possible to individually optimize the accuracy of each placement machine 22', 22", 22"' by means of statistics (average per placement machine).

In the situation shown in Fig. 8D the image 71 is obtained from joining images produced by means of separate cameras 23', 23'', 23'''. In this way no extra camera is needed to produce the image 71, but use can be made of cameras already present in the placement machines. The information 77 obtained from the individual images as well as the joint image 71 can be relatively extensive. This method is particularly suitable if the measuring time and processing time is longer than the time necessary for placing a component on a substrate.

It is alternatively possible to produce a number of different images of different regions of different substrates by means of a single camera, from which, subsequently, a joint image is assembled.

Fig. 9 shows a control diagram of an in-line situation where components are placed on a substrate by means of a system 1, after which images of the components placed on the substrate are produced by means of a machine 4. Information 81 relating to the desired positions of the component on the substrate is fed to the control diagram 6. These nominal positions are stored in a unit 8. The desired positions are corrected via the feedback 12, after which the value U thus obtained is fed to the placement machines 2', 2", 2'''. These placement machines 2', 2", 2''' are shown by block 82 in the control diagram 6. Components are positioned on the substrates on the basis of this information. Deviations n1 owing to, for example, friction, measuring errors, wear and vibrations then occur. Deterministic errors are part of the placement process, for example the placement process shows adjustment errors. Subsequently, images are produced by the machine 4. This is shown as block 7 in Fig. 9. During the production of the images deviations n2 occur which may be the result of measuring noise and calibration errors when the camera is positioned over the substrate. In an adding element 83 the real component positions relative to the substrate calculated from the images are compared with the desired component positions relative to the substrate known from unit 8. The resulting difference E =)Y is fed to a low-pass filter 10 and then processed in unit 11, after which a feedback signal 12 is obtained. In adding element 84 this feedback signal 12 is then combined, as described above, with information 81 with regard to the desired position of components on a substrate.

If a relatively large amount of information is to be processed, which is impossible for example within a period of time necessary for placing components on a substrate, it is better to not produce images for detecting deviations between real and desired positions of components on a substrate on line, but off line. This method as well as the control diagram 91 necessary for this is shown in Fig. 10. The control diagram 91 largely

corresponds with the control diagram 6 as shown in Fig. 9, except that the device 4 is not installed, as shown in Fig. 1, near the system 1, but is completely separated from it. The device 4 can for example be installed in a separate laboratory. It may be obvious that the off-line detection of differences between real and desired positions of components on a substrate, a relatively large time delay is obtained between the moment of placing the components on the substrate and then the adaptation of the driving of the placement machines for component placement on a next substrate.

It is alternatively possible to both verify the positions of a limited number of components in line and verify the positions of all components off line.

It is possible to process in the algorithm 11 information of the real and desired positions of a specific component as it is positioned on a number of substrates. This provides as it were an average over time of the real and desired positions by the use of, for example, digital filters.

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CLAIMS:

1. A method of placing at least one component (25) on at least one substrate (24), a component (25) being picked up by means of at least a placement machine (2) and placed on a desired position on the substrate (24), characterized in that after the component (25) has been placed on the substrate (24), an image of the component (25) placed on the substrate (24) is made by a camera (5, 23), a difference between the real position of the component (25) on the substrate (24) and the desired position of the component (25) on the substrate (24) being established on the basis of the image, after which the positioning of a next component (25) to be placed is adapted on account of the difference found.

2. A method as claimed in claim 1, characterized in that first a same kind of component (25) is placed on a number of substrates (25) on substantially the same positions, while differences between the desired and real positions of the components (25) relative to the associated substrates (24) are determined, the positioning of a next component (25) to be placed on a next substrate (24) being adapted on account of the differences found.

3. A method as claimed in claim 1 or 2, characterized in that first on at least one substrate (24) a number of different components (25) are positioned, the real positions of which are compared with the desired positions, subsequent to which the positioning of a next component (25) to be placed on the substrate (24) or another substrate is adapted based on a statistically determined average difference.

4. A method as claimed in one of the preceding claims, characterized in that once a number of components (25) have been placed, the real positions are compared with the desired positions.

5. A method as claimed in one of the preceding claims 1 to 3, characterized in that once each component (25) has been placed, the real position is compared with the desired position.

6. A method as claimed in one of the preceding claims, characterized in that components (25) are placed on at least a substrate (24) by means of a number of placement machines (2) located side by side, each placement machine (2) comprising a camera (5, 23) by means of which an image of at least a portion of the substrate (24) is produced to

determine the difference between the desired and real positions of the component (25) placed on the substrate (24).

7. A method as claimed in claim 6, characterized in that from images produced by means of the placement machines (2) of respective portions of the substrate (24) a joint image is produced of the substrate (24) and the components (25) positioned thereon.

8. A system suitable for implementing the method as claimed in any one of the preceding claims, characterized in that the system comprises at least a placement machine (2) and a camera (5, 23) cooperating with the placement machine (2), an image of a component (25) positioned on a substrate (24) by means of the placement machine (2) being producible by means of the camera, the placement machine further comprising a processor by means of a real position of the component (25) relative to the substrate (24) as well as a difference with a desired position of the component (25) relative to the substrate (24) can be determined from the image produced by the camera (5, 23).

9. A system as claimed in claim 8, characterized in that a drive of the placement machine (2) can be adapted by the processor on account of the difference found.

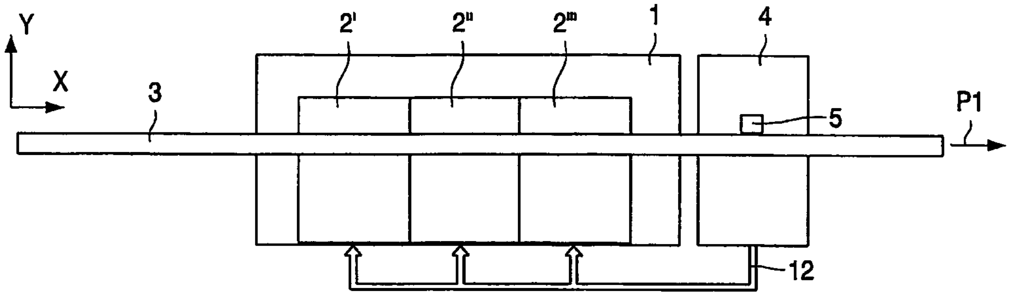

FIG. 1

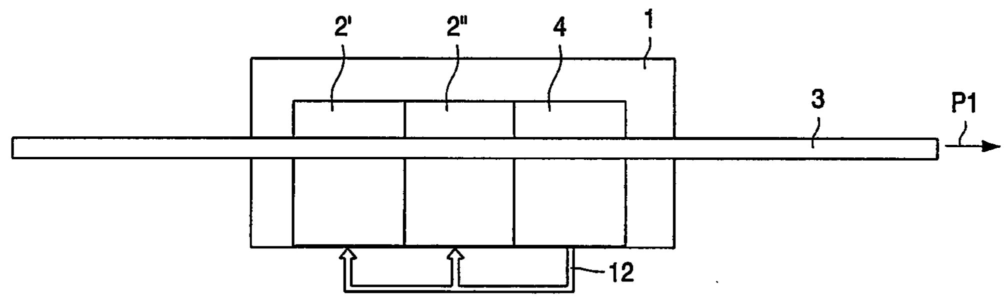

FIG. 2

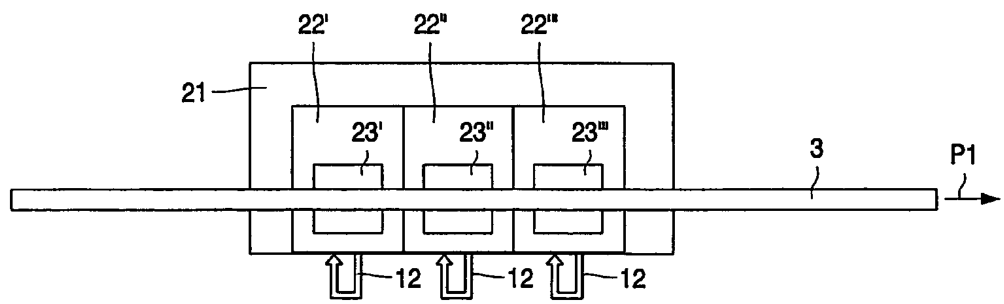

FIG. 3

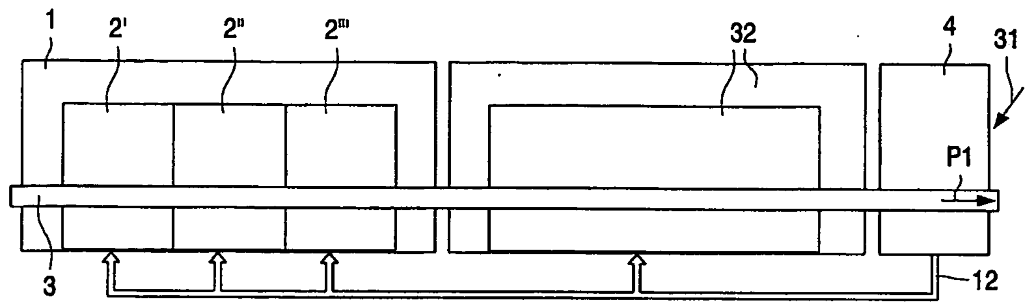

FIG. 4

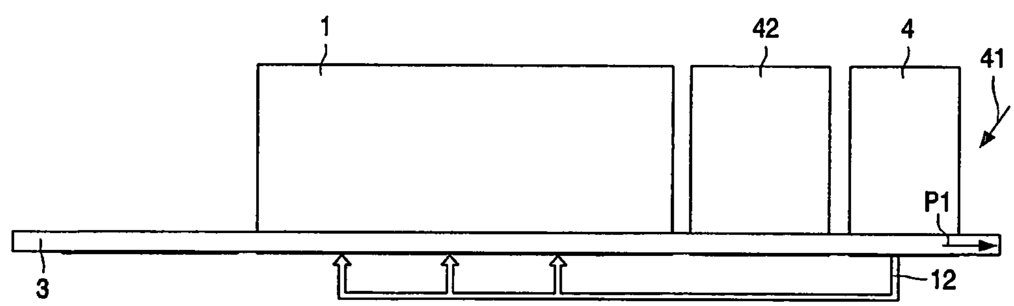

FIG. 5

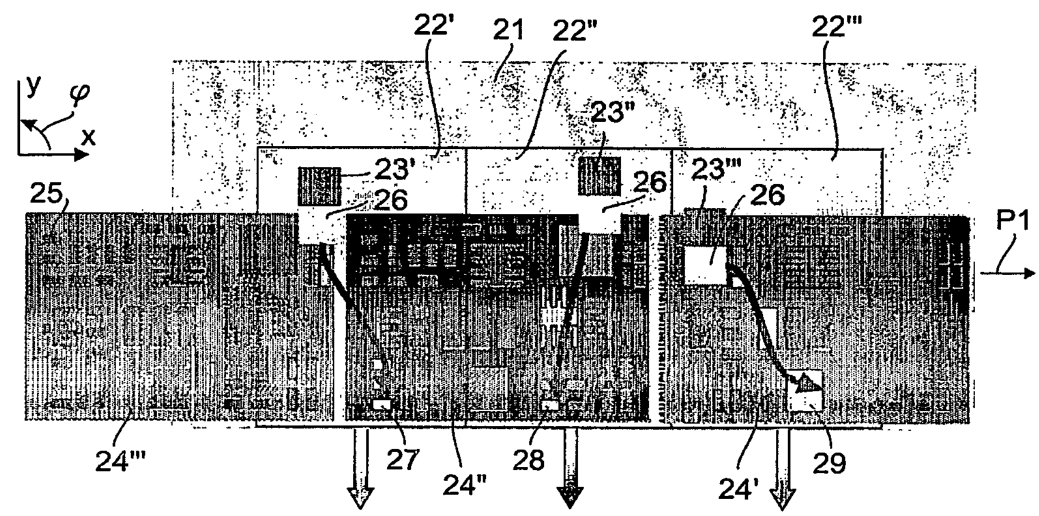

FIG.6A

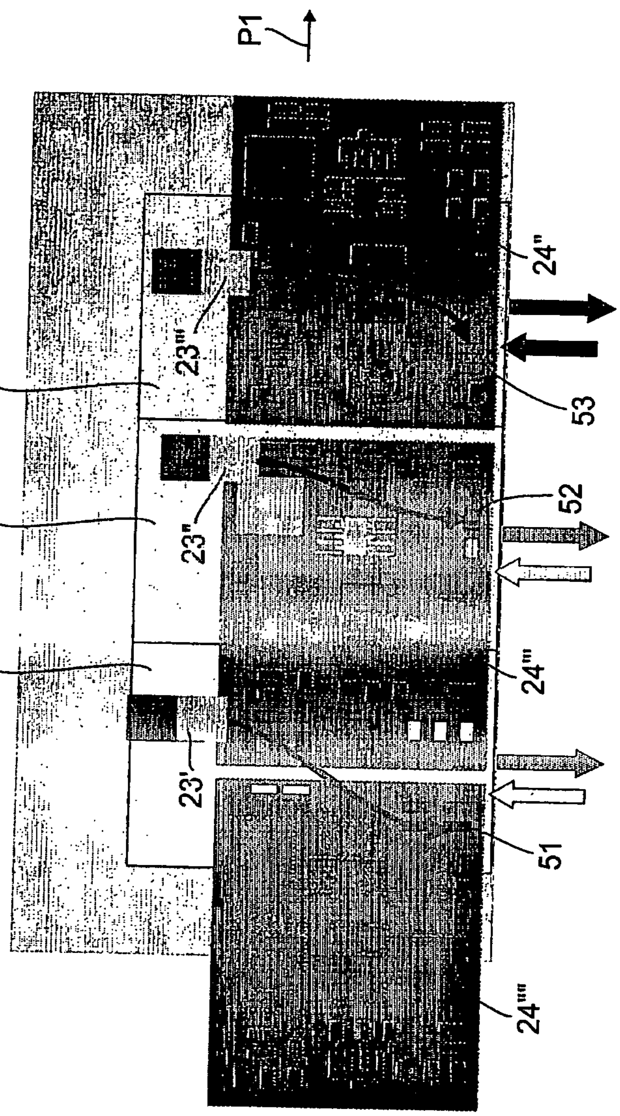

FIG.6B

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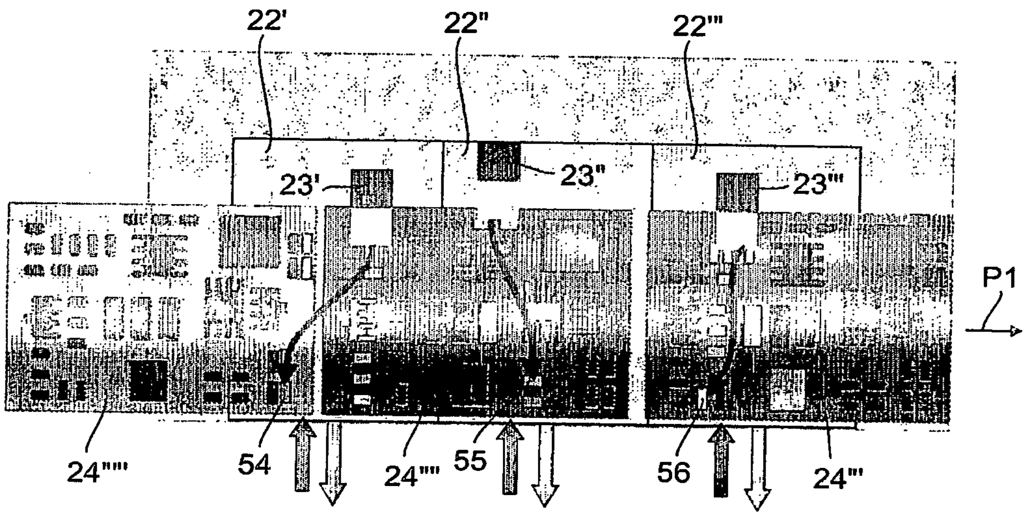

FIG.6C

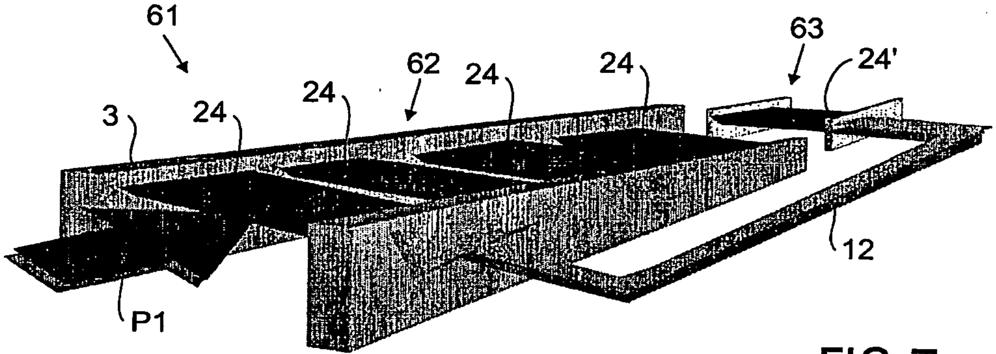

FIG.7

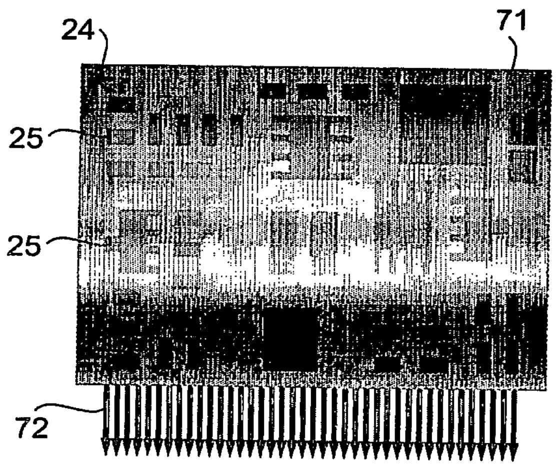

FIG.8A

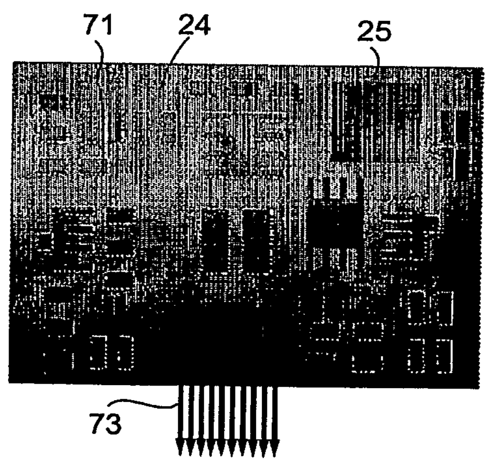

FIG.8B

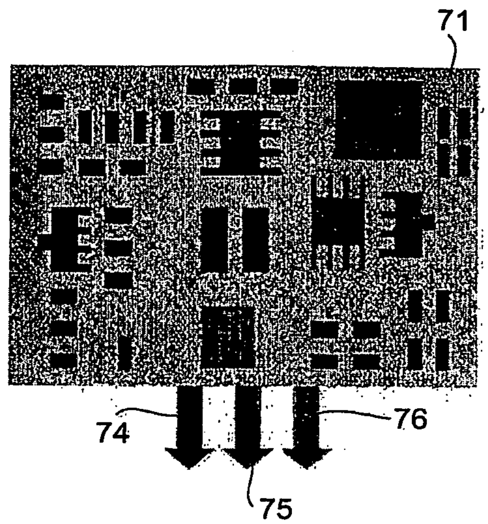

FIG.8C

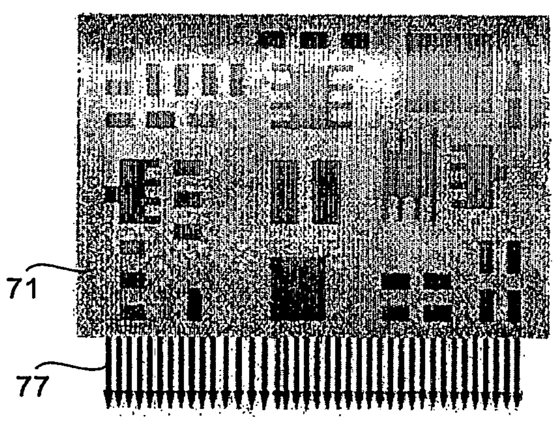

FIG.8D

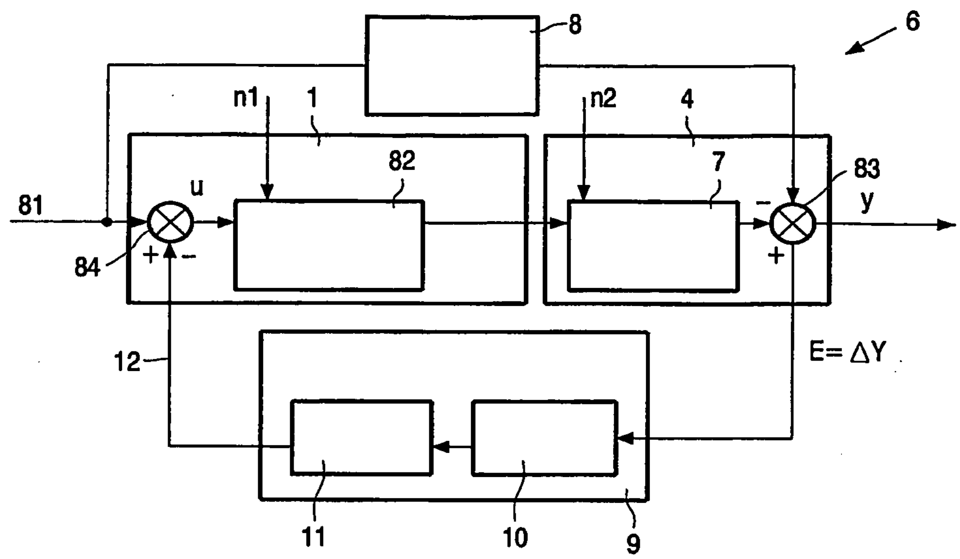
8
6
n1
1
n2
4
82
7
83
81
u
y
84
E= ΔY
12
11
10
9

FIG. 9

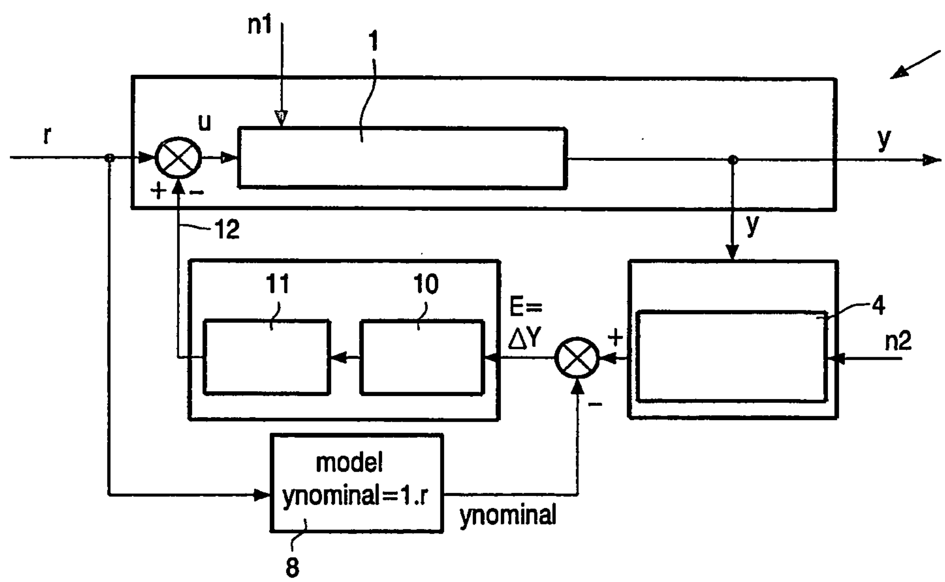
n1
1
91
r
u
y
12
y
11
10
E=
ΔY
4
n2
model
ynominal=1.r
ynominal
8

FIG. 10